MASTER OF SCIENCE
IN
MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

RENDERING LARGE-SCALE TERRAIN MODELS AND POSITIONING OBJECTS IN RELATION TO 3D TERRAIN

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In this thesis, a method is presented for rendering 3D terrain and placing objects on that terrain. The terrain is based on Digital Terrain Elevation Data (DTED) and represents real world terrain. The terrain is built relative to an ellipsoid based model of the earth and is therefore accurately displayed with curvature of the earth. Objects are then placed on the terrain with the proper elevation determined by the terrain objects themselves along with the proper orientation. Using these constructs, users can build terrain models of places all over the earth and move objects on that terrain with minimal effort. A final benefit is that all of the constructs built in this thesis are based upon open standards in the Virtual Reality Modeling Language, Extensible 3D Graphics, and Java. Thus, the code in this thesis can be used by anyone without acquiring any licenses.

KEYWORDS: Virtual Reality Modeling Language, VRML, GeoVRML, X3D, Extensible 3D Graphics, Terrain, Digital Terrain Elevation Data, DTED

THE EXTENSIBLE RUN-TIME INFRASTRUCTURE (XRTI): AN EXPERIMENTAL IMPLEMENTATION OF PROPOSED IMPROVEMENTS TO THE HIGH LEVEL ARCHITECTURE

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The establishment of a large-scale network of persistent shared virtual worlds depends on the presence of a robust standard for communicating state information between the applications that host and provide access to those worlds. The High Level Architecture (HLA) can serve as the basis for such a standard, but not before several of its shortcomings are resolved. First, it must be made easier to use. Second, it must specify a standardized message protocol. Third, it must support dynamic object model extension and composition. Finally, its authors must provide an open-source, freely redistributable run-time infrastructure.

This thesis documents the creation of the Extensible Run-Time Infrastructure (XRTI), an experimental platform that addresses the above requirements while retaining full backwards compatibility with the existing HLA standard. To increase ease-of-use, the XRTI provides a proxy compiler that generates customized sets of Java™ source files based on the contents of arbitrary Federation Object Model Document Data (FDDs). To encourage message protocol standardization, the XRTI uses a novel bootstrapping methodology to define its low-level interactions in terms of an HLA object model. The XRTI supports the dynamic composition and extension of such object models through its Reflection Object Model (ROM), and this thesis demonstrates that ability by depicting the integration of the XRTI into NPSNET-V, a dynamically extensible platform for virtual environment applications.

KEYWORDS: High Level Architecture, HLA, Run-Time Infrastructure, RTI, NPSNET, Networked Virtual Environments, Network Protocols, Middleware, Open-Source, Java, Dynamic Extensibility, Code Generation, Interoperability, Distributed Simulation

CREATING DIGITAL ENVIRONMENTS FOR MULTI-AGENT SIMULATION

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There are few tools available for military and civilian simulation developers to quickly and efficiently develop high-fidelity digital environments capable of supporting high-resolution, agent-based simulation. In this work, the author has tried to lay a solid foundation for further understanding the digital terrain support available to simulation developers.

This thesis explores numerous digital terrain data representations and tools available to create digital environments. The work explores the specific problem of terrain database generation for agent-based ground combat simulation. To accomplish this, the author explores the more general problem of where to find the data, what tools are available, and how to put the pieces together to create a registered digital environment on a state-of-the-art computer. The author envisions this methodology to be the first step in the design of an automated planning tool capable of importing real world digital terrain data and quickly generating agent-based military combat scenarios for any location on earth.

This work provides a logical construct and design methodology for an analyst to create high fidelity terrain data sets. It functions as a “how to” manual to help analysts understand which information and tools are available to use for different types of simulation projects.

KEYWORDS: Synthetic Natural Environment, Terrain Data Representation, Terrain Data Format, Agent-Based Modeling, Multi-Agent Systems, Complex Adaptive Systems